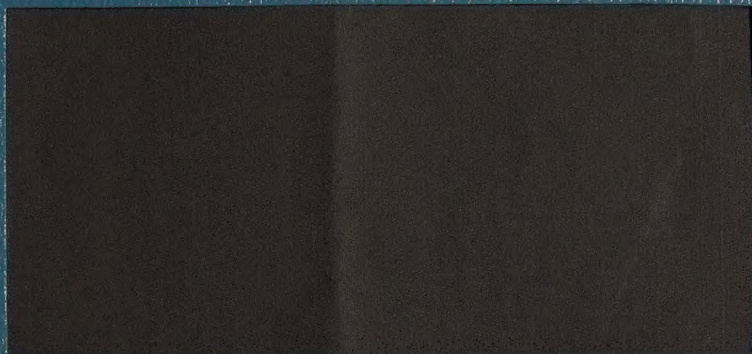
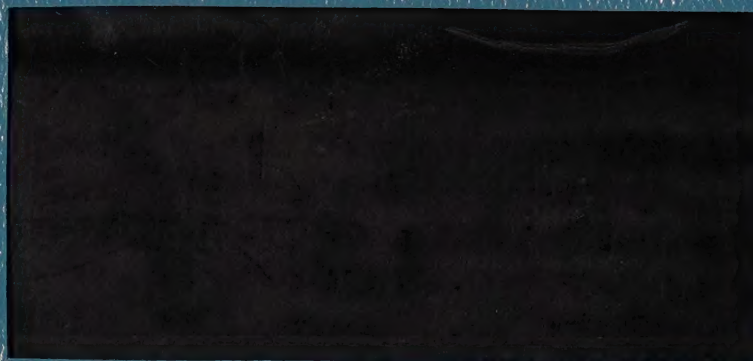






FILE COPY

INSTRUCTION AND MAINTENANCE MANUAL

ITHACO 450 SERIES

DATA ACQUISITION AMPLIFIERS

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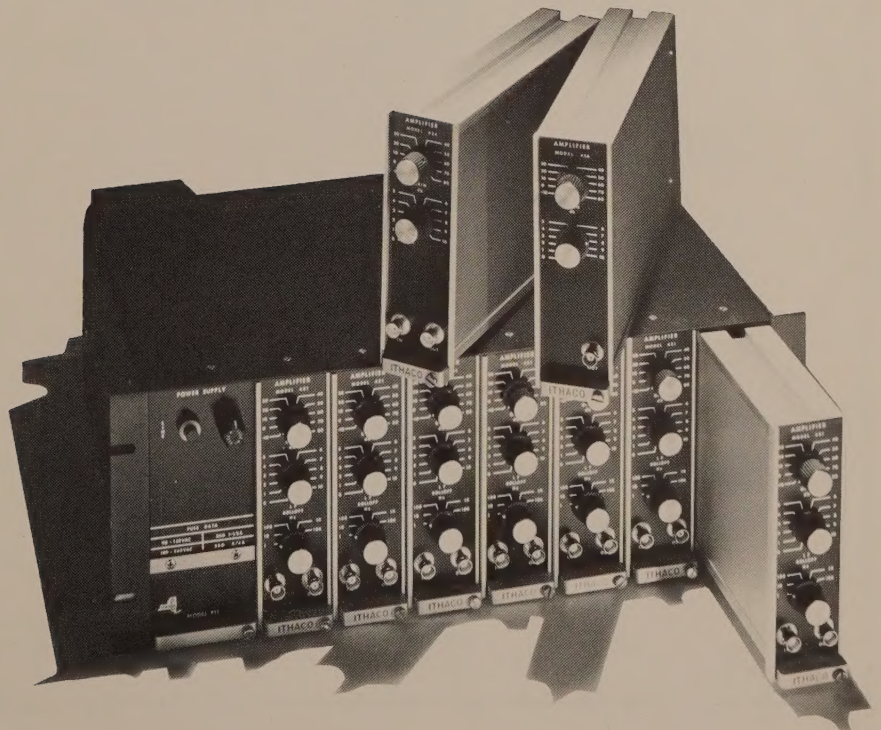
DECEMBER, 1978

ITHACO INC.
735 West Clinton Street
Ithaca, New York 14850
Telephone 607-272-7640

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	Elementary Diagrams	
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ITHACO
ac instrumentation
amplifiers
450 series



450 SERIES INSTRUMENTATION AMPLIFIERS

- For general purpose use in acquisition and conditioning of dynamic (AC) signals
- 1 Hz to 100 kHz bandwidth
- 1% gain accuracy
- 2° phase accuracy
- 100 dB gain range in 1dB steps
- Low noise, low distortion
- No gain switching transients - fast overload recovery

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RELATED ITHACO PUBLICATIONS

<i>IPS 104</i>	<i>"Variable Electronic Filters"</i>
<i>IPS 112</i>	<i>"Low Noise Preamplifiers"</i>
<i>IPS 115</i>	<i>"AUTO-GAIN® Amplifiers"</i>
<i>IAN 102</i>	<i>"Measuring Noise Spectra with Variable Electronic Filters"</i>

PHASE AND FREQUENCY RESPONSE

Figure 1 shows the phase and frequency response of all 450 Series Models. Great care has been taken to maintain precise amplitude and phase tracking (2% and 2° respectively) between like amplifiers. This relationship is maintained through and below the -3 dB point in models

with adjustable LF rolloff controls operating on the same rolloff setting. The solid curves show broadband performance of all models, and the dashed curves show response of the various LF rolloff positions of Models 451, 453, and 455.

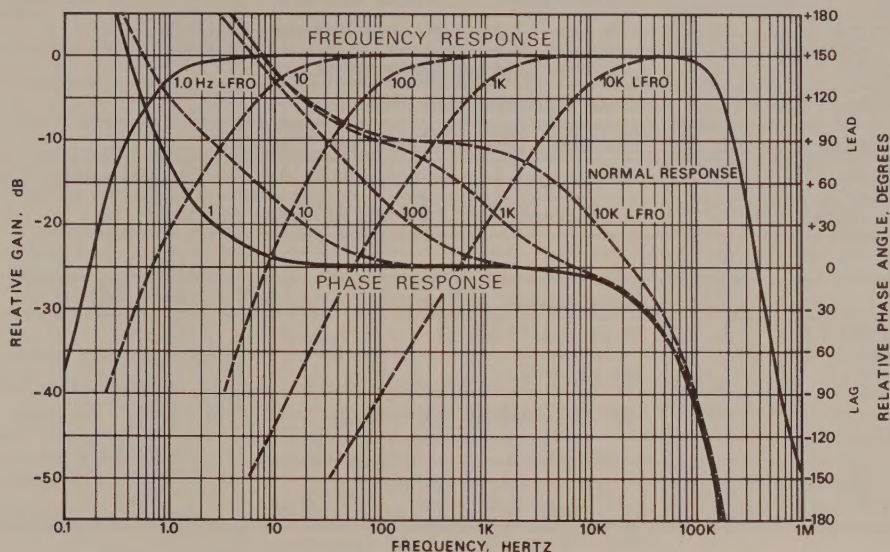
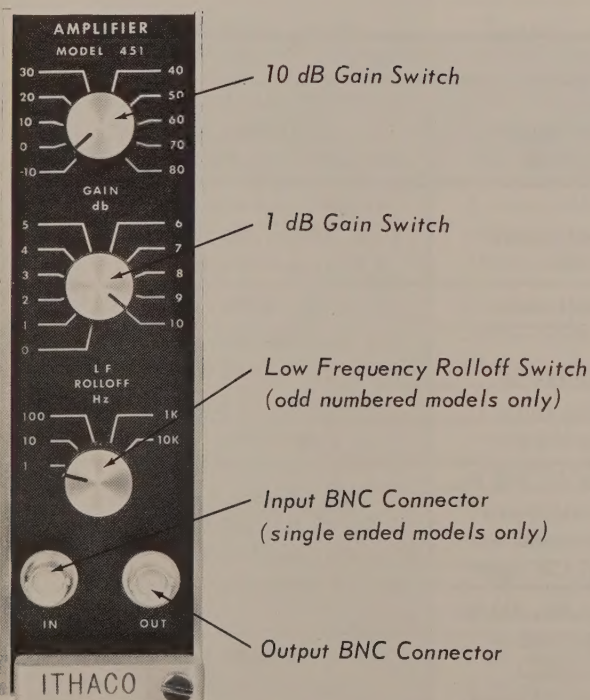
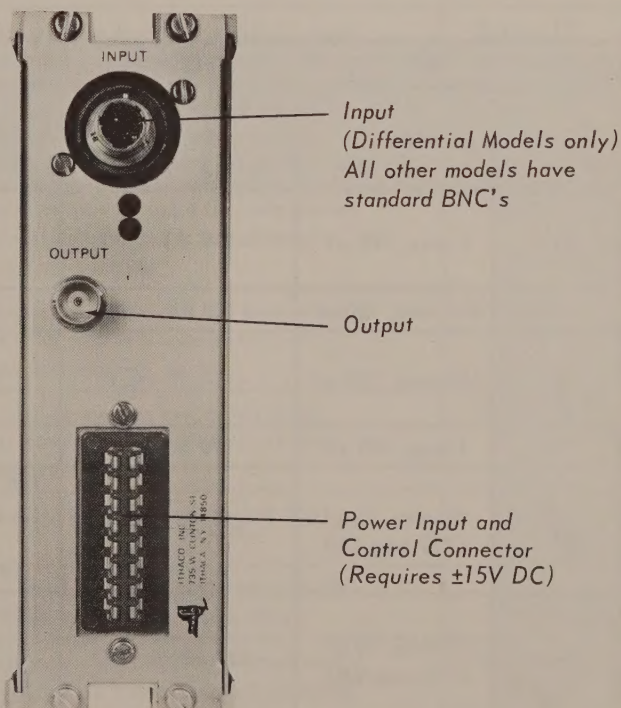


Figure 1 Phase and Frequency Response of 450 Series Amplifiers

FRONT PANEL



REAR PANEL



SPECIFICATIONS - ALL MODELS

COMMON SPECIFICATIONS

TRANSFER CHARACTERISTICS	
GAIN RANGE	-10 dB to +90 dB in 1 dB steps
GAIN ACCURACY	±1% plus loading effect of 20Ω output impedance
GAIN STABILITY	±1% with time and temperature
HIGH FREQUENCY CUTOFF	-3 dB maximum @100 kHz
PHASE RESPONSE	Inverting (180° midband, see Figure 1)
PHASE ACCURACY	±2° maximum between channels with same rolloff setting (10 Hz to 30 kHz)
HARMONIC DISTORTION	¼% maximum with 1.0V rms output in passband
OUTPUT	
IMPEDANCE	20 Ω maximum (DC coupled with 10mV maximum DC offset)
MAXIMUM OUTPUT	7V pk and 15 mA pk
NOISE	See page 10
ENVIRONMENT	-20 °C to +55 °C Operating; -55 °C to +85 °C Storage; R.H. 95%
POWER	±15V @35 mA Models 455 and 456 -55V @12 mA see page 8
DIMENSIONS AND WEIGHT	6.75" high x 2" wide x 10.5" deep 3 lbs.

OTHER SPECIFICATIONS

MODEL	INPUT IMPEDANCE	BROADBAND NOISE * SHORTED INPUT	COMMON MODE REJECTION	LOW FREQUENCY CUTOFF 6 dB OCTAVE SLOPE	MAXIMUM INPUT
451	1 meg, 100 pf	-110 dB (3μV)	Not Applicable	-3 dB selectable at 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz	±7V pk
452	500 meg, 100 pf	-108 dB (4μV)	Not Applicable	-3 dB @1 Hz	±7V pk
453	500 meg, 100 pf	-108 dB (4μV)	Not Applicable	-3 dB selectable at 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz	±7V pk
454	1 meg, 100 pf	-110 dB (3μV)	Not Applicable	-3 dB @1 Hz	±7V pk
455	20 meg, 10 pf (100 meg CM)	-104 dB (6.3μV)	100 dB from 60-400 Hz 60 dB anywhere in passband 5V pk max CM input	-3 dB selectable at 1 Hz, 10 Hz, 100 Hz, 1 kHz, and 10 kHz	±5V pk
456	20 meg, 10 pf (100 meg CM)	-104 dB (6.3μV)	100 dB from 60-400 Hz 60 dB anywhere in passband 5V pk max CM input	-3 dB @1 Hz	±5V pk

* see page 10

OPTIONS

OPTION	DESIGNATION	DESCRIPTION	MOUNTING CASE OPTION
01	Vernier Gain Control	1 dB step control replaced with 10 dB gain vernier	—
03	Remote Preamp +28 Volt Power	5 pin XLR connector added to rear panel to supply +28 volt power and signal connections to remote preamplifier. Models 451 and 454 only.	—
04	Meter	Front panel meter added. 1½" dial, 3% accuracy, 2 volt rms full scale, average reading. Models 452, 454, 456 or by deleting 1 dB switch on 451, 453, 455.	—
05	Low Frequency Cutoff	6 dB/octave low frequency cutoff changed to customer specified value between 1 Hz and 10 kHz. Models 452, 454, 456 only.	—
06	High Frequency Cutoff	12 dB/octave high frequency cutoff changes to customer specified value between 20 kHz and 100 kHz. (Output Filter)	—
09	Remote Preamp ±15 Volt Power	5 pin XLR connector added to rear panel to supply ±15 volt power and signal connections for remote preamp. Models 451 and 454 only.	—
10 *	Remote Preamp Calibration System	Adds calibration system for use with specific remote preamps (see page 6 for cal system and page 9 for preamps). Models 451 and 454 only.	—
16	Connector Modification	Changes any existing connector to different connector type.	—
18	Selectable High and Low Frequency Cutoff	5 selectable 6 dB/octave frequency cutoffs added with customer specified frequencies between 500 Hz and 100 kHz	—
19	Remote Control 10 dB Gain Step	"Remote" position added to front panel 10 dB step control. (See description, page 7)	Option 19
20	Gain Status Readout 10 dB Control	4 wires added to rear connector for 4 bit gain code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
21	Gain Status Readout 1 dB Control	4 wires added to rear connector for 4 bit gain status code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
22	Frequency Cutoff Status Readout	3 wires added to rear connector for 3 bit frequency status code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
23	Status Readout All Controls (see Options 20, 21, 22)	11 wires added to rear connector for status code. 1 wire added to rear connector for channel strobe. (See description, page 6)	Option 23
24	Twinaxial BNC	Twinaxial BNC for differential input. Model 455 and 456 only.	—
25	5 dB Manual Gain Control	5 dB manual gain control (20 position) and a 10 dB gain vernier in 1 dB steps from -5 dB to +5 dB	—
26	5 dB Manual/Remote Gain Control	5 dB manual/remote gain control (20 position) and a 10 dB gain vernier in 1 dB steps from -5 to +5 dB (see page 7)	Option 19

*Cal Option 10 not available in combination with Option 09 because of pin limitations on preamp connector

OPTIONS (CONTINUED)

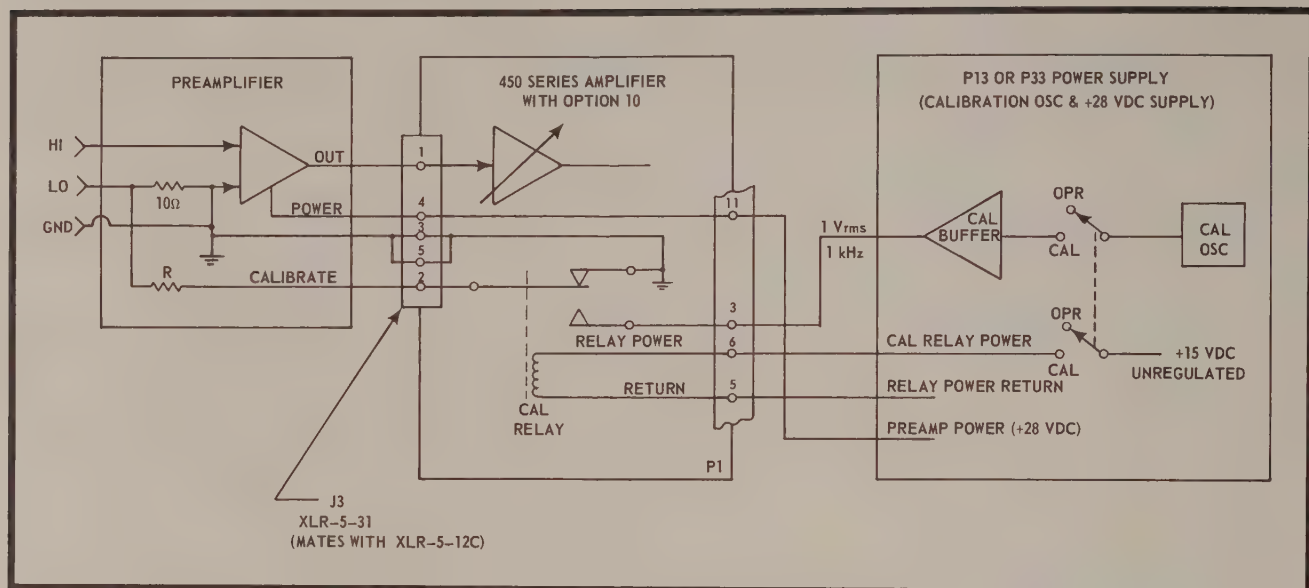


Figure 2 450 Series Calibration System – Option 10

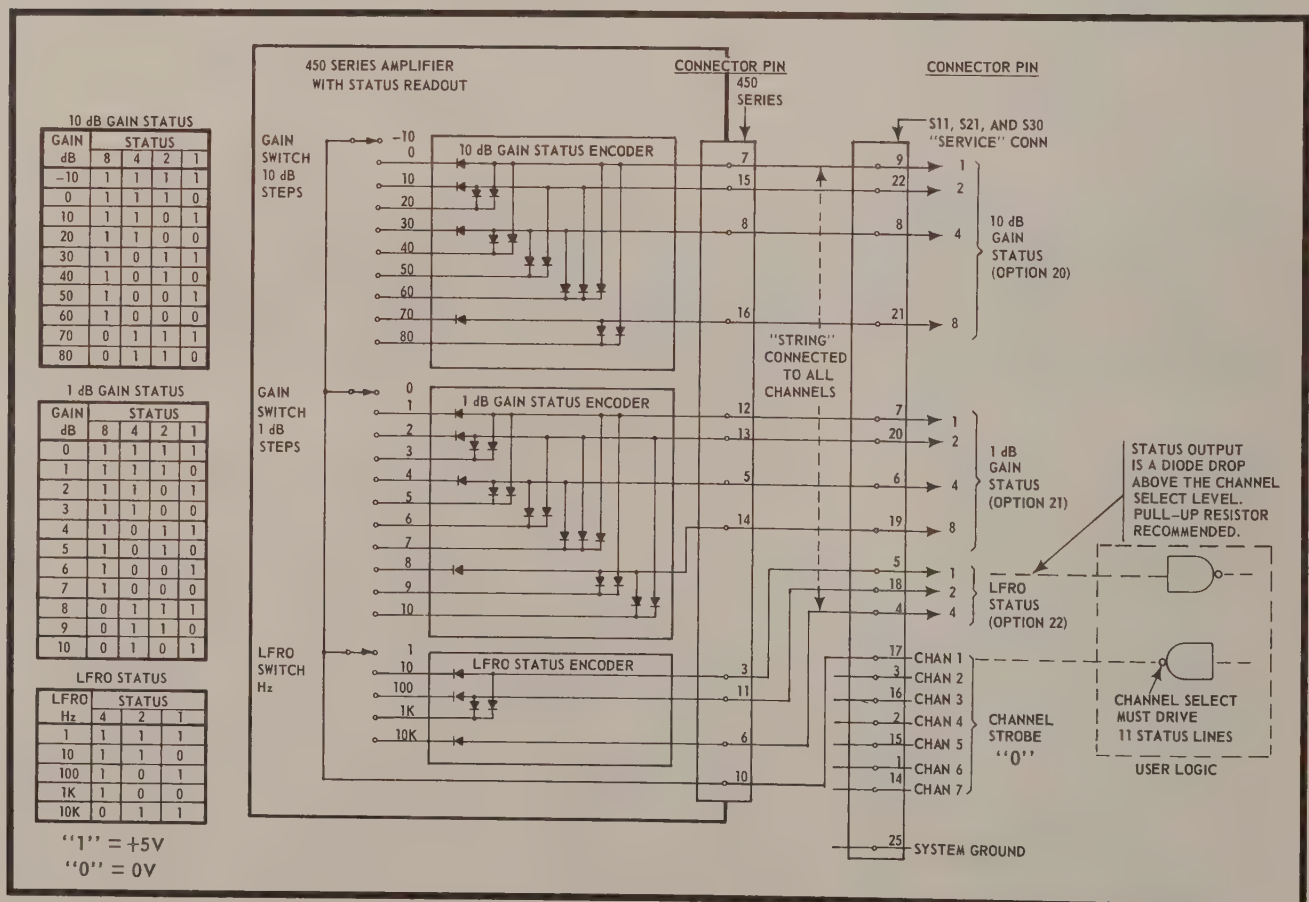
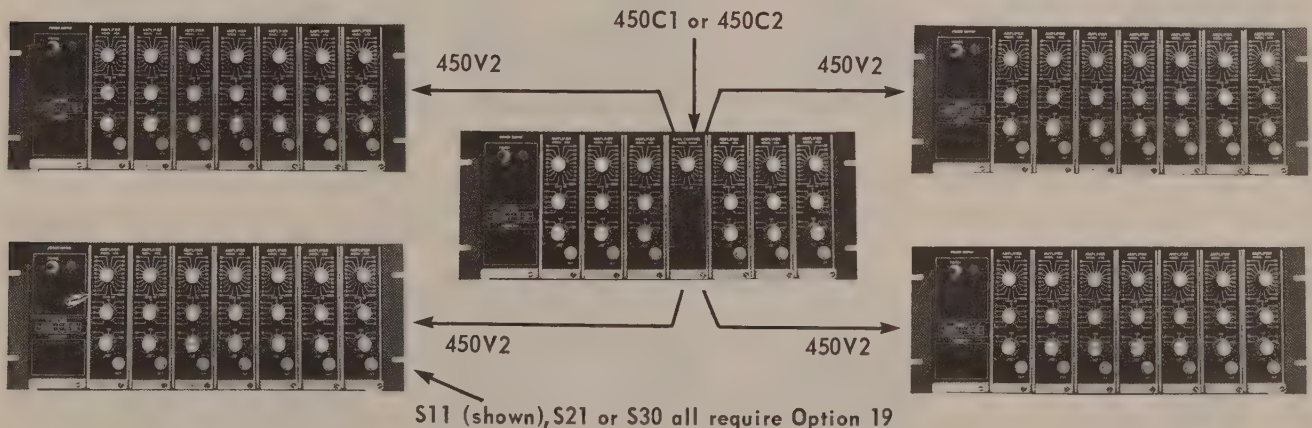


Figure 3 450 Series Status Readout – Options 20, 21, 22, and 23

REMOTE GAIN CONTROL OPTIONS

(Simultaneous Gain Control of up to 34 Amplifiers)

 451 (Option 19) 450C1	 451 (Option 26) 450C2
10 dB REMOTE GAIN CONTROL 450 SERIES AMPLIFIERS WITH OPTION 19 (Manual/Remote Control of 10 dB gain steps) 450C1 Remote Gain Control Unit S11, S21, or S30 Cases all require Option 19 P Series Power Supplies 450V2 Cable (one required for each additional case)	5 dB REMOTE GAIN CONTROL 450 SERIES AMPLIFIERS WITH OPTION 26 (Manual/Remote Control of 5 dB gain steps) 450C2 Remote Gain Control Unit S11, S21, or S30 Cases all require Option 19 P Series Power Supplies 450V2 Cable (one required for each additional case) NOTE: Maximum output reduced for gain vernier setting between -2 dB and -5 dB. (Maximum output at least 4V rms)



REMOTE GAIN CONTROL SYSTEM

A Remote Gain Control System can be formed by plugging a remote control unit in a case with Option 19 along with 450 Series Amplifiers with a remote gain control option. Up to four additional cases of amplifiers can be controlled by a remote gain control unit via 450V2 Convenience Cables. In systems employing more than one power supply, the control unit will continue to operate as long as one of the cases contains an operating power supply.

Figure 4 Remote Gain Control Options – Options 19 and 26

ACCESSORIES

POWER SUPPLIES

MODEL	POWER	DESCRIPTION	MTG. CASE
P11	$\pm 15\text{V}/1\text{A}$	Use with 451, 452, 453, 454 and most Options	S11, S21
P12	$\pm 15\text{V}/1\text{A}$, $+28\text{V}/.2\text{A}$	Use with 451 and 454 with Option 03	S11, S21
* P13	$\pm 15\text{V}/1\text{A}$, $+28\text{V}/.2\text{A}$	Use with 451 and 454 with Option 01	S11, S21
P14	$\pm 15\text{V}/1\text{A}$, $-55\text{V}/.1\text{A}$	Required for 455 and 456	S11, S21
* P33	$\pm 15\text{V}/.5\text{A}$, $+28\text{V}/.1\text{A}$	Use with 451, 452, 453, 454, Opt 03 and 10	S30
* P34	$\pm 15\text{V}/.5\text{A}$, $-55\text{V}/.05\text{A}$	Required for 455 and 456	S30
* P37	$\pm 15\text{V}/.5\text{A}$	Use with 451, 452, 453, 454 and most options	S30

* Equipped with Cal Oscillators



POWER SUPPLY FEATURES

- POWER SUPPLY REGULATION $\pm 15\text{V}$.05% line, .01% load
- SHORT CIRCUIT PROTECTED
- LINE FREQUENCY 47 – 440 Hz
- BATTERY POWER INPUT ON REAR CONNECTOR

POWER SUPPLY OPTIONS

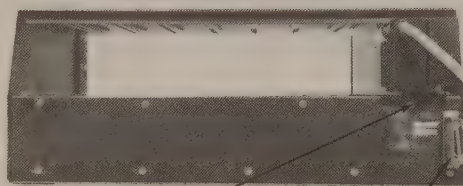
- STANDARD 105V – 130V
- OPTION 01 90V – 110V
- OPTION 02 180V – 220V
- OPTION 03 210V – 260V

MOUNTING CASES

MODEL S11
7 CHANNEL MOUNTING CASE



DIMENSIONS: 7" high x 19" wide x 14" deep
WEIGHT: 25 lbs. including power supply



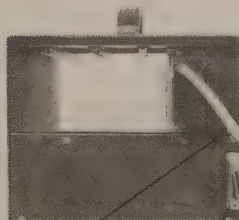
Ground Link

Service Connector

MODEL S21
3 CHANNEL PORTABLE CASE



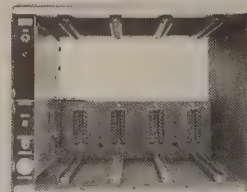
DIMENSIONS: 7.2" high x 9.1" wide x 12.3" deep
WEIGHT: 15 lbs. including power supply



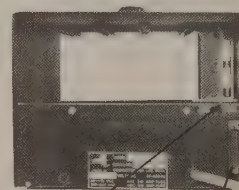
Ground Link

Service Connector

MODEL S30
4 CHANNEL PORTABLE CASE



DIMENSIONS: 7.2" high x 9.1" wide x 14.2" deep
WEIGHT: 12 lbs. including power supply

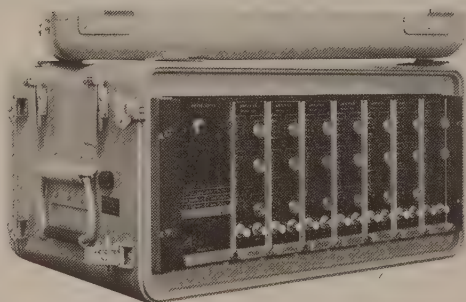


Ground Link

Service Connector

ACCESSORIES (Continued)

TRANSIT CASES (CONSULT FACTORY FOR ADDITIONAL INFORMATION)



- Heavy Duty Aluminum
- Weatherproof Covers
- Carrying Handles

- TC4 4 CHANNEL TRANSIT CASE
(use for S21-04 and S30-04 Mounting Cases)
- TC7 7 CHANNEL TRANSIT CASE
(use with S11 Mounting Case)

OTHER ACCESSORIES

450V1	PREAMP CABLE (Connects amplifier with preamplifier)
450V2	CONVENIENCE CABLE (Connects 450C1 or 450C2 with mounting cases)
A11516	LOCKING POWER CONNECTOR
X1	6 FOOT EXTENDER CABLE (Blank Plug-In with extender cable)
Y1	BLANK FRONT PANEL
Z1	EMPTY AMPLIFIER CHASSIS

MATING CONNECTORS

Use With	Description	Manufacturer Part Number	ITHACO Part Number
S11, S21, S30 Cases	Service Connector on rear panel	Cannon DBM-25P	A11234G1
Models 455, 456	Differential input connector	KPT06B8-4S	812104004
Options 03, 09, 10	5 pin XLR connector	Cannon XLR-5-12C	812123005
Option 24	Twinaxial BNC	Amphenol 31-224	812130108

PREAMPLIFIERS

SPECIFICATIONS

MODEL	143L	144L	 Model 144L
INPUT	Single-Ended	Single-Ended	
INPUT Z	100M // 25pF	100M // 25pF	
BANDWIDTH	.5 Hz - 200 kHz	.5 Hz - 200 kHz	
GAIN	10 (20dB)	100 (40dB)	
OUTPUT VOLTS	±8V	±8V	
POWER SUPPLY VOLTAGE	+28V	+28V	
NOISE	See page 10		

* For other applicable preamplifiers, see ITHACO Bulletin IPS 112 "Low Noise Preamplifiers"

NOISE

SPECIFICATIONS

	451, 454	452, 453	455, 456
BROADBAND NOISE (maximum)	dB re 1 volt rms referred to input, measured at 25°C and at maximum gain		
Shorted Input	-110 dBV (3μV)	-108 dBV (4μV)	-104 dBV (6.3μV)
1000 pf Source	---	-106 dBV (5μV)	-104 dBV (6.3μV)
100 pf Source	---	-100 dBV (10μV)	- 99 dBV (11μV)
SPECTRAL NOISE (maximum)	(1 Hz BW in dB re 1 volt rms, measured at 25°C and at maximum gain)		
Shorted @100 Hz	-150 dBV (32nV/√Hz)	-148 dBV (40nV/√Hz)	-142 dBV (80nV/√Hz)
Input @ 10 kHz	-161 dBV (9nV/√Hz)	-159 dBV (11nV/√Hz)	-155 dBV (12nV/√Hz)
1000 pf @100 Hz	---	-145 dBV (55nV/√Hz)	-155 dBV (12nV/√Hz)
Source @ 10 kHz	-160 dBV (10nV/√Hz)	-159 dBV (11nV/√Hz)	-154 dBV (20nV/√Hz)
OUTPUT NOISE	600μV rms broadband at minimum gain, measured at 25°C		

TO COMPUTE AMPLIFIER OR PREAMPLIFIER NOISE FOR ANY SOURCE IMPEDANCE AND ANY BANDWIDTH:

In Figure 5, Z_s is the complex impedance of the source. e_n and i_n are input stage noise voltage and current respectively. Total noise E_n referred to the input is:

$E_n = \sqrt{[e_n^2 + (i_n Z_s)^2]} \text{ BW}$, where BW is the bandwidth of interest. For broadband computations where e_n and i_n are not constant:

- Divide bandwidth of interest into small intervals.
- Compute noise for each such interval using the average values of e_n and i_n for that interval.
- Make an rms summation of the noise for all intervals to find E_n (see IAN-102).

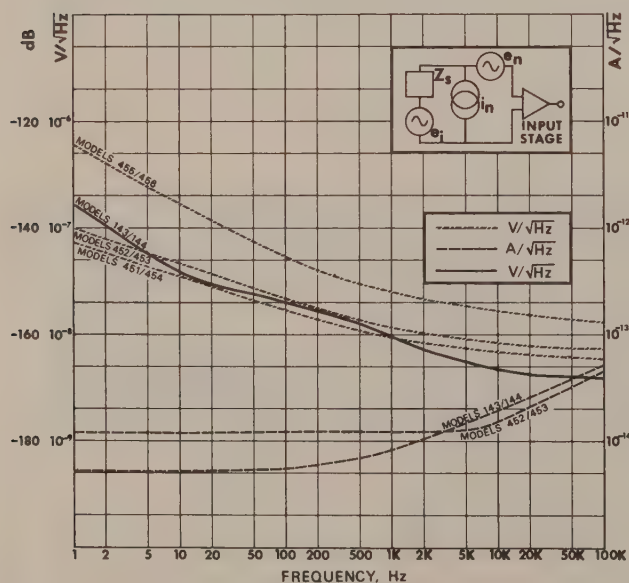


Figure 5 Spectral Noise of Amplifiers and Accessory Preamplifiers

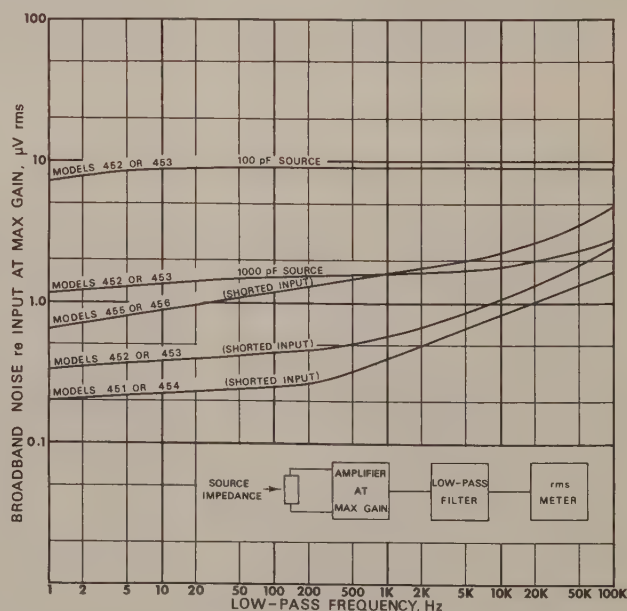


Figure 6 Broadband Noise as a Function of Bandwidth

ITHACO PRODUCTS INCLUDE:

scientific and engineering

lock-in amplifiers, light beam choppers, ratiometers, low noise preamplifiers, electronic filters

data acquisition

instrumentation amplifiers, seismic amplifiers, auto-ranging amplifiers, voltage-controlled amplifiers, compression amplifiers, computer-controlled amplifiers, charge amplifiers, dynamic strain amplifiers, low noise preamplifiers, multiple channel electronic filters, anti alias filters

agricultural

ultrasonic instruments for live animal evaluation

spacecraft

horizon scanners and attitude control system components



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SECTION 2

2.0 OPERATING INSTRUCTIONS

2.1 MOUNTING AND OPERATION

2.1.1 INDEPENDENT AMPLIFIER

1. Make the following connections to a 16 pin Blue Ribbon connector which mates with Amphenol #26-4100-16P:

<u>Pin</u>	<u>Connection</u>
1	-15v $\pm$ 1%
2	Signal Ground
9	+15v $\pm$ 1%
4	-55v $\pm$ 3% (Models 455 & 456)
11	Preamp Power (Option 03)

2. Connect (1) to rear connector on amplifier. Connect Signal Source and output monitoring equipment to appropriate BNC connectors.

CAUTION: Since the amplifier package is at signal ground, care should be taken to insulate it from chassis or power ground. Otherwise undesirable ground currents may result.

3. Set desired gain and low frequency rolloff. The low frequency rolloff approaches 6 dB/octave below the frequency set by the front panel switch marked $\sqrt{\text{Hz}}$. As long as the input signal remains below 14v p-p, the amplifier output stage will saturate before the input stages regardless of low frequency rolloff or gain setting.
4. Apply DC power and begin operation.

2.1.2 AMPLIFIER IN S11 RACKMOUNT

1. Mount the S11 Rackmount in a 19" standard RETMA relay rack.
2. Plug up to 7 channels of 450 Series Amplifiers into rackmount. Insert power supply channel in extreme left slot only.
3. Connect power supply power cord to 117v, 60 Hz line, and turn power supply on.
4. Connect signal sources and output monitoring equipment to appropriate BNC connectors.

5. Set desired gain and low frequency rolloff, and begin operation.

2.1.3 AMPLIFIER IN S21 PORTABLE CASE

1. Plug up to three channels of 450 Series Amplifiers into portable case leaving the extreme left slot vacant. Plug power supply in extreme left slot.
2. Connect power supply power cord to 117v, 60 Hz line, and turn power supply on.
3. Connect signal sources and output monitoring equipment to appropriate BNC connectors.
4. Set desired gain and low frequency rolloff, and begin operation.

2.1.4 POWER SUPPLIES

1. Models 451, 452, 453 and 454 use Model P11 supply.
2. Models 455 and 456 use Model P14 supply.
3. Option 03
Use Model P12 for positive preamp power.
Use Model P15 for negative preamp power.

2.1.5 EXTERNAL PREAMP POWER (OPTION 03)

Rear panel input BNC replaced by 5 pin XLR connector (J3).

J3-1	INPUT
J3-3	Ground
J3-4	Preamp Power

2.1.6 DIFFERENTIAL INPUT CONNECTOR - Models 455 and 456

Rear panel input BNC replaced by KPT Differential Input Connector.

A	Inverting Input
B	Common Mode
C	Non-Inverting Input
D	Common Mode

SECTION 3

3.0 THEORY OF OPERATION

3.1 INTRODUCTION

The internal organization of the 450 Series Amplifiers is shown in Figure 3.1. Basically, the amplifier consists of a unity gain input stage, 0/10/20/30 dB attenuator, 20 dB gain stage, 0/10/20/30 dB attenuator, 30 dB gain stage, 0/10/20/30 dB attenuator, 30 dB gain stage, 1 dB step attenuator, and 10 dB gain stage. Each of 0/10/20/30 dB attenuators is electronically switched from the front panel 10 dB/step gain switch. The 10 dB attenuator is mechanically switched by the front panel 1 dB/step gain switch. The third front panel control, the Low Frequency Rolloff switch, electronically switches four of the five rolloff capacitors, the remaining capacitor being the input coupling capacitor.

The 450 Series Amplifiers contain input and output BNC's on both the front and rear panels. The input BNC's are tied in parallel, as are the output BNC's.

Since the 450 Series makes extensive use of modular, solid-state circuitry, the following discussion will be on a module basis.

3.2 INPUT STAGE AND ATTENUATOR (A-1)

As is evident from Figure 3.1, the incoming signal is coupled into the input unity gain stage by the 1 Hz and 10 Hz rolloff capacitors. The former is always present in all models, the latter being present only when the 10 Hz rolloff position (451, 453 and 455 only) is activated from the front panel. The unity gain input stage is a high input impedance, low noise FET stage. This stage drives attenuator #1 which is electronically switched and provides 0 dB attenuation for all amplifier gain settings above 20 dB. The second unity gain stage is a complimentary pair which drives the 100, 1K, and 10 KHz rolloff coupling capacitors (451, 453 and 455 only).

3.3 FIRST STAGE AMPLIFIER (A-3)

The First Stage Amplifier contains the 100 Hz rolloff capacitors, (451, 453 and 455 only), and a fixed 20 dB gain amplifier. The amplifier is an inverting operational amplifier, fed back for 20 dB gain.

3.4 SECOND STAGE AMPLIFIER AND ATTENUATOR I AND II (A-4, A-5)

Following the First Stage Amplifier is a second 30 dB electronically switched 0/10/20/30 dB attenuator and a 30 dB operational amplifier. The attenuator provides 0 dB attenuation for overall gains above 50 dB, and 30 dB attenuation for overall gains below 20 dB. The 30 dB oper-

ational amplifier has a FET input and a complimentary output stage which is not current limited. Thus, care should be taken to avoid shorting the output during maintenance.

The above module is repeated as the Second Stage Amplifier and Attenuator II. The output of this stage drives an R, L, C low pass filter, tuned and damped to provide less than 3 dB of rolloff at 100 KHz.

Following the high frequency rolloff is the 10 dB, fine attenuator physically located on the front panel which provides 10 dB of attenuation in 1 dB steps.

3.5 OUTPUT STAGE (A-8)

The final amplification stage consists of a 10 dB differential amplifier with a complimentary output stage. This stage also contains a current limiting feature which prevents amplifier damage, should the DC coupled output be short circuited. The gain of the output stage is adjustable to provide for overall amplifier gain trim. This adjustment consists of a potentiometer on the main board.

3.6 LOW FREQUENCY ROLLOFF SWITCH (A-6) (451, 453 and 455 only)

The Low Frequency Rolloff Switch Module contains the biasing circuitry and control points for the solid-state rolloff switches. The front panel switch merely serves to switch decoupled -15v to the appropriate control point in this module.

3.7 ROLLOFF MODULE (A-2) (451, 453, 455 only)

This module consists of the solid-state switches and rolloff capacitors for the 1 KHz and 10 KHz rolloff settings. It derives its control and bias voltages from the module discussed in 3.6.

3.8 POWER ISOLATOR (A-7)

The Power Isolator Module is a pair of grounded base stages which decouple and filter the DC power used by the Input Stage and First Stage amplifiers. This makes the first stages of amplification less sensitive to dynamic power supply noise, and provides power line isolation between the first stage amplifiers and the remainder of the amplifier.

TABLE I

AMPLIFIER SECTION

Gain (dB)	-10	0	10	20	30	40	50	60	70	80	90*
Overall											
Input v rms	3.16	1.0	.316	.1	.0316	.01	.00316	.001	.000316	.0001	.0000316
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Input Stage A1											
Input v rms	3.16	1.0	.316	.1	.0316	.01	.00316	.001	.000316	.0001	.0000316
Output rms	100 mv	100 mv	100 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv	.1 mv	.0316 mv
Pin 5 VDC	+8	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15
Pin 6 VDC	-15	+8	-15	-15	-15	-15	-15	-15	-15	-15	-15
Pin 14 VDC	-15	-15	+8	-15	-15	-15	-15	-15	-15	-15	-15
Pin 16 VDC	-15	-15	-15	+8	+8	+8	+8	+8	+8	+8	+8
First Stage (A3)											
Input rms	100 mv	100 mv	100 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv	.1 mv	.0316 mv
Output v rms	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv
Second Stage #1 (A4)											
Input v rms	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv	3.16 mv	1.0 mv	.316 mv
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv
Pin 2 VDC	+8	+8	+8	+8	-15	-15	-15	-15	-15	-15	-15
Pin 1 VDC	-15	-15	-15	-15	+8	-15	-15	-15	-15	-15	-15
Pin 18 VDC	-15	-15	-15	-15	-15	+8	-15	-15	-15	-15	-15
Pin 19 VDC	-15	-15	-15	-15	-15	-15	+8	+8	+8	+8	+8
Second Stage #2 (A5)											
Input v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	316 mv	100 mv	31.6 mv	10 mv
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.316
Pin 2 VDC	+8	+8	+8	+8	+8	+8	+8	-15	-15	-15	-15
Pin 1 VDC	-15	-15	-15	-15	-15	-15	-15	+8	-15	-15	-15
Pin 18 VDC	-15	-15	-15	-15	-15	-15	-15	-15	+8	-15	-15
Pin 19 VDC	-15	-15	-15	-15	-15	-15	-15	-15	-15	+8	+8
Output Stage (A8)											
Input v rms	.316	.316	.316	.316	.316	.316	.316	.316	.316	.316	.316
Output v rms	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

*Indicates Fine Gain Switch in 10 dB position. All other measurements require the Fine Gain Switch to be in the 0 dB position.

SECTION 4

4.0 CALIBRATION AND MAINTENANCE

4.1 INTRODUCTION

The extensive use of modular, solid-state circuitry makes calibration and maintenance of the 450 Series extremely easy. The amplifier side panels may be removed to provide access to the main card by removing the two screws at the rear of each side panel, and sliding the side panel toward the rear of the amplifier. The left side panel provides access to the component side of the main board.

4.2 CALIBRATION

4.2.1 OUTPUT OFFSET

1
With no signal input and the amplifier at minimum gain, adjust the left hand potentiometer, (R6), on the main board until the output offset is within 2 mv of ground.

4.2.2 OVERALL AMPLIFIER GAIN

2
At a frequency of 1 KHz, rolloff of 1 Hz, and 0 dB of gain, adjust the right hand potentiometer, (R7), on the main board until gain is $0 \text{ dB} \pm 0.1 \text{ dB}$.

4.2.3 HIGH FREQUENCY ROLLOFF

Set gain to 0 dB and low frequency rolloff to 1 Hz. With an input signal of 1v rms at 160.0 KHz, short R4 on the main board and adjust L1 until the amplifier output reaches its peak value. Remove the short from R4 and check output at 100 KHz level. Output should be 1.5 to 2 dB below its 1 KHz level.

CAUTION: Be sure to use nylon or plastic tool to adjust L1 in order to avoid damaging the ferrite slug or obtaining an incorrect adjustment.

4.3 MAINTENANCE

4.3.1 INTRODUCTION

The modular construction techniques used in the 450 Series permit rapid fault isolation. No attempt should be made to repair a module, but rather it should be replaced. However, unless the user has suitable equipment for removing the modules, and is familiar with solid-state circuitry, the amplifier should be returned to the factory for repair. The only tools

which are necessary to remove modules are a soldering iron attachment which applies uniform heat to all module pins simultaneously, and a tool for lifting the module off the main board. Even with these tools, care must be taken to heat only the points to be removed, to prevent destruction of the printed circuit pads and runs. After removing a module, excess solder must be removed from the holes in the main board prior to installing a new module.

In an emergency, a module may be removed as follows: desolder each module pin from a motherboard using an Edsyn Standard Module "Soldapullet" or equivalent desoldering tool. Insure that the pins are free by carefully moving them from side to side with long-nose pliers. Lift the module from the board, insert a new module, and resolder all pins. During the desoldering and soldering process care must be taken to avoid heating the pins and printed circuit runs for longer than four or five seconds at a time. If this limit is exceeded, loss of printed circuitry may result.

The following troubleshooting procedure is recommended for user convenience. In any event, maintenance should only be attempted by persons familiar with solid-state circuitry.

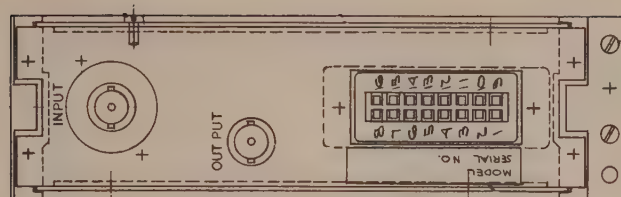
4.3.2 AMPLIFIER FAILURE

To assist in troubleshooting a failure in the amplifier or gain control circuitry, Table I and main board drawings are provided. All signal voltages in Table I are approximate except the output voltage. Thus, minor deviations do not necessarily mean a malfunction has occurred. DC voltages in Table I should be measured with a probe of 10 megohm impedance or greater. The measurements in Table I are valid for the fine gain switch set in the 0 dB position except for the 90 dB column. For this column, the fine gain switch should be set to 10 dB.

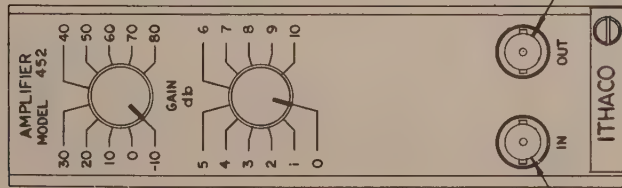
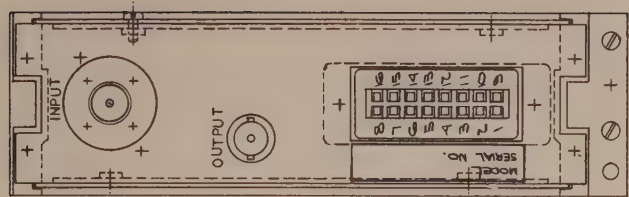
The ± 15 VDC lines should read ± 15 VDC $\pm 1\%$, and the decoupled ± 15 VDC lines should read approximately ± 13 VDC $\pm 1v$.

Modular pin designations have a 1R designation on the main board for pin Number 1 and each pin position is counted whether or not there is a pin in that location. In addition, Pin 12 is designated 12R on the main board to further assist in counting pins. Again it must be pointed out that in determining pins, it is the location that must be counted rather than the actual pins.

NOTE: Because of overall amp gain adjustment in output stage, AC measurements are approximate. Gain status logic uses 10 meg pull-up R, measurements should be made with 10 meg, or greater, probe. If +8 levels measure +3 or greater, signal level is o.k.

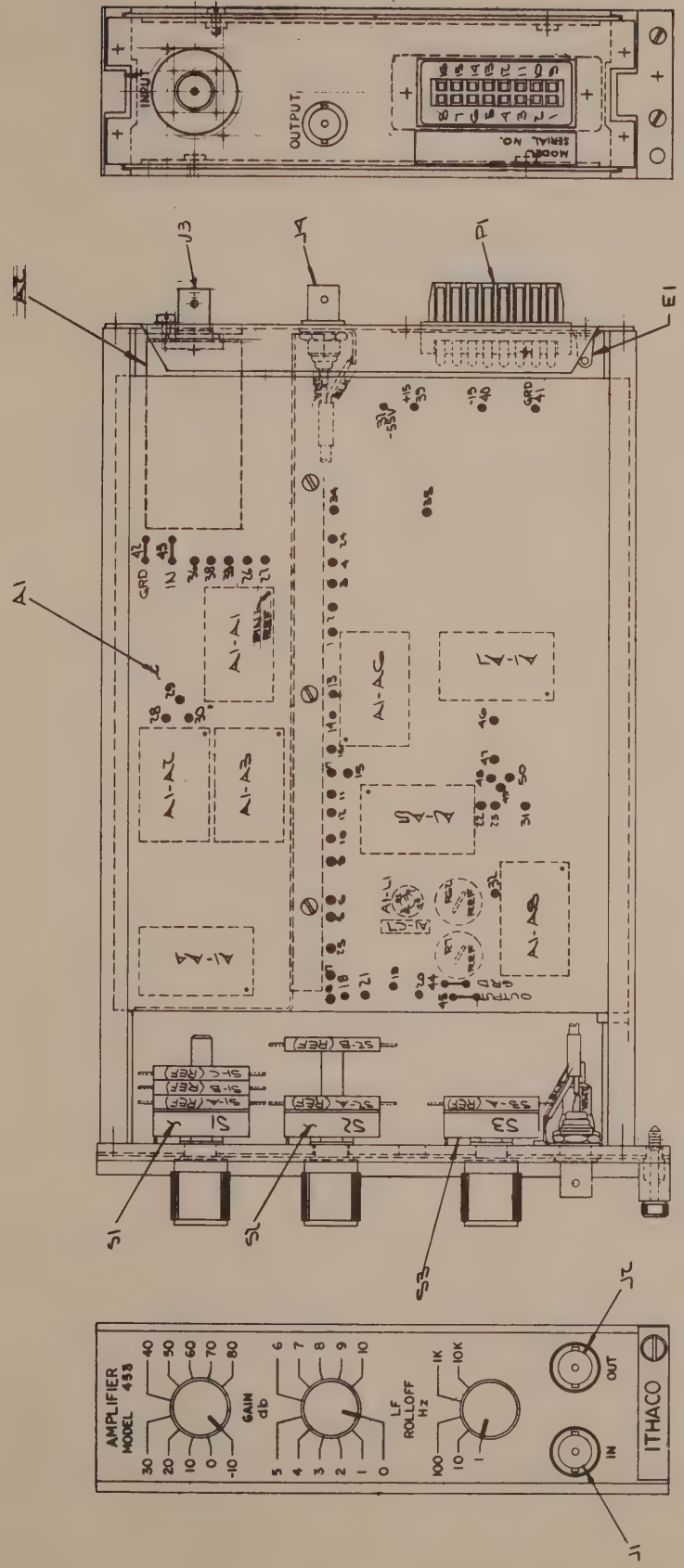
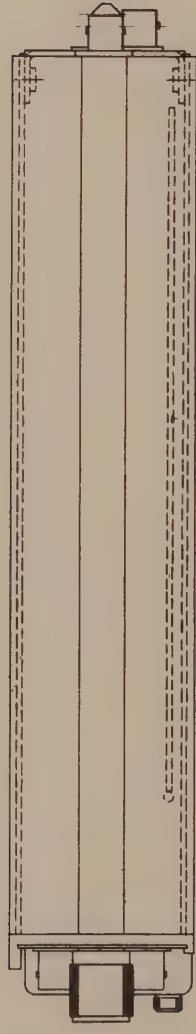


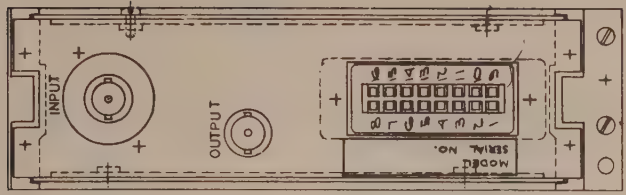
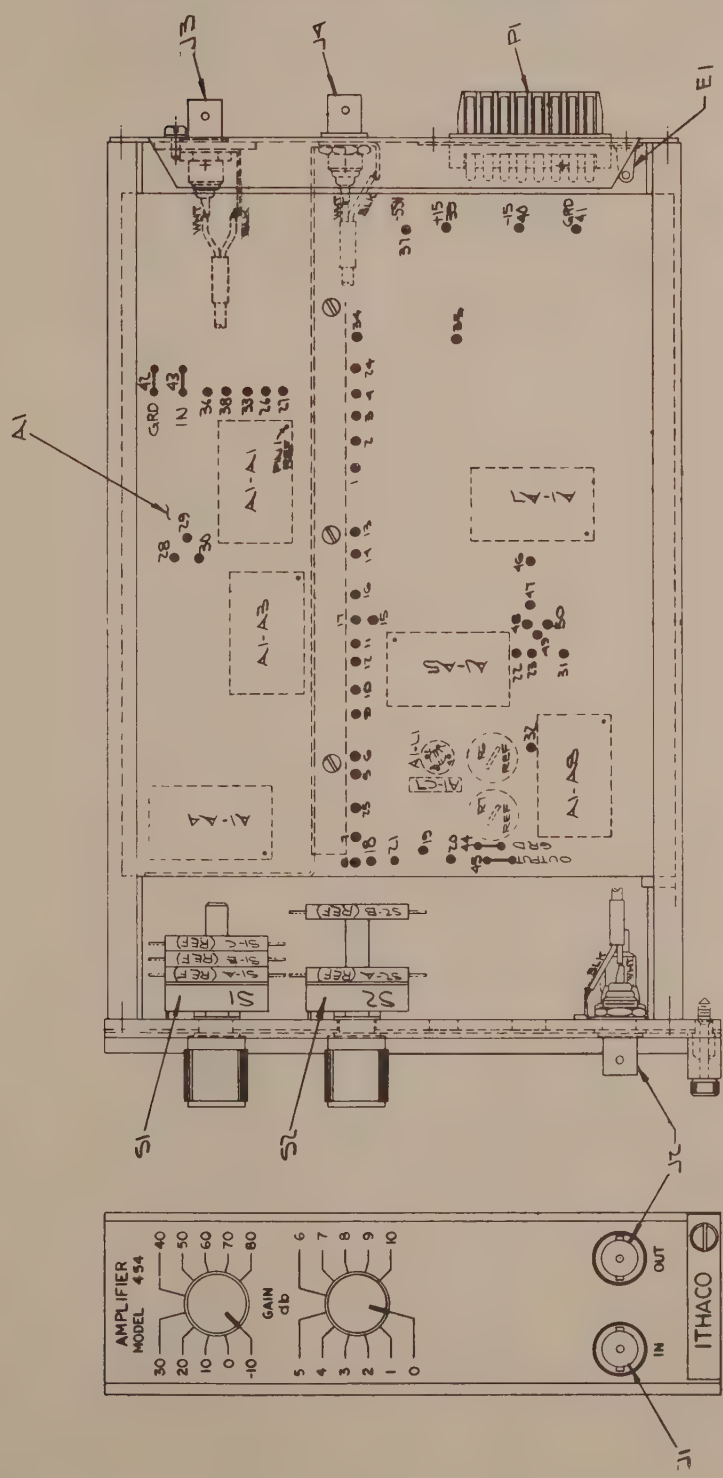
MODEL 451 AMPLIFIER ASSEMBLY



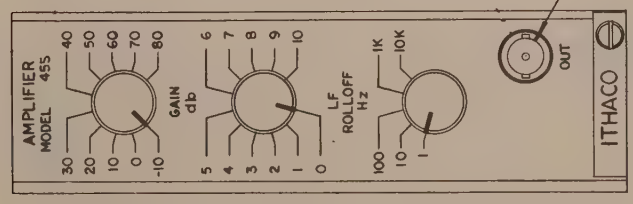
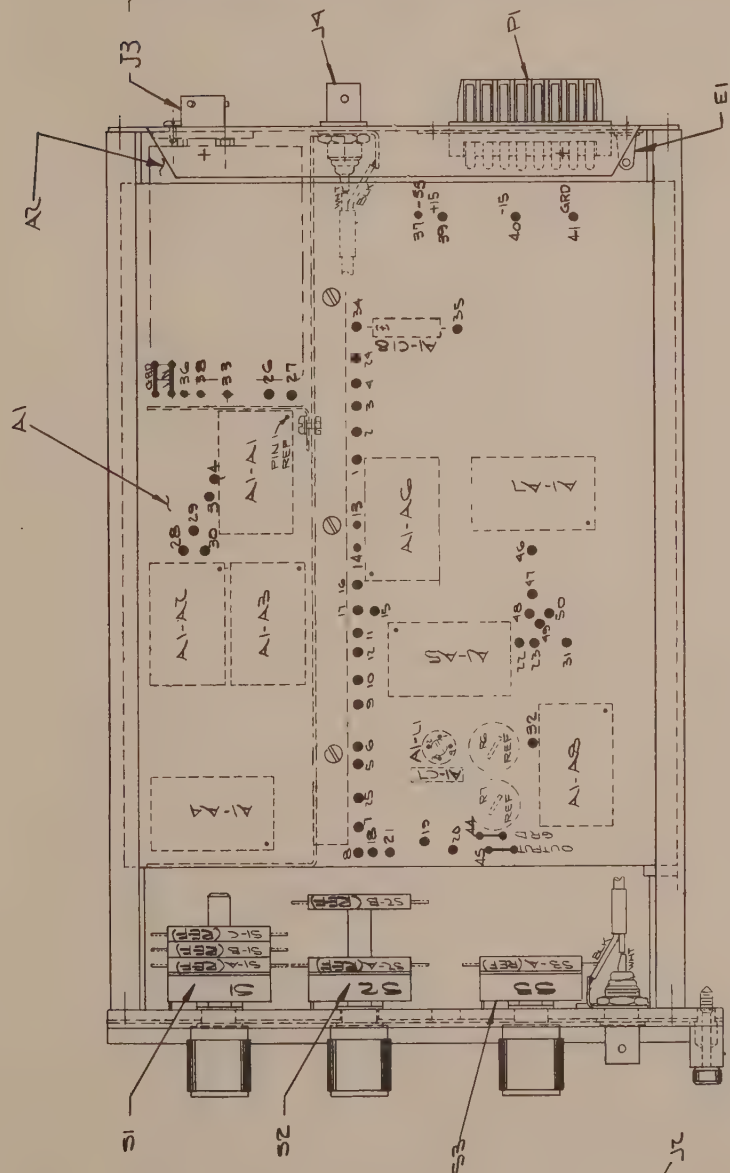
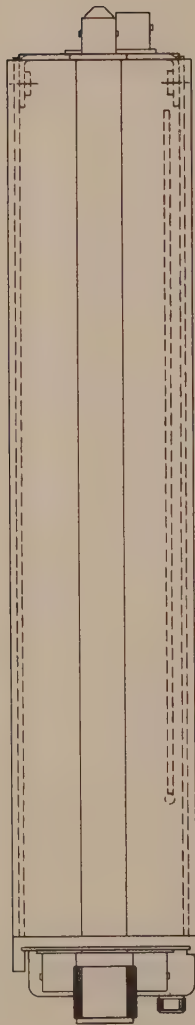
MODEL 452 AMPLIFIER ASSEMBLY

MODEL 453 AMPLIFIER ASSEMBLY

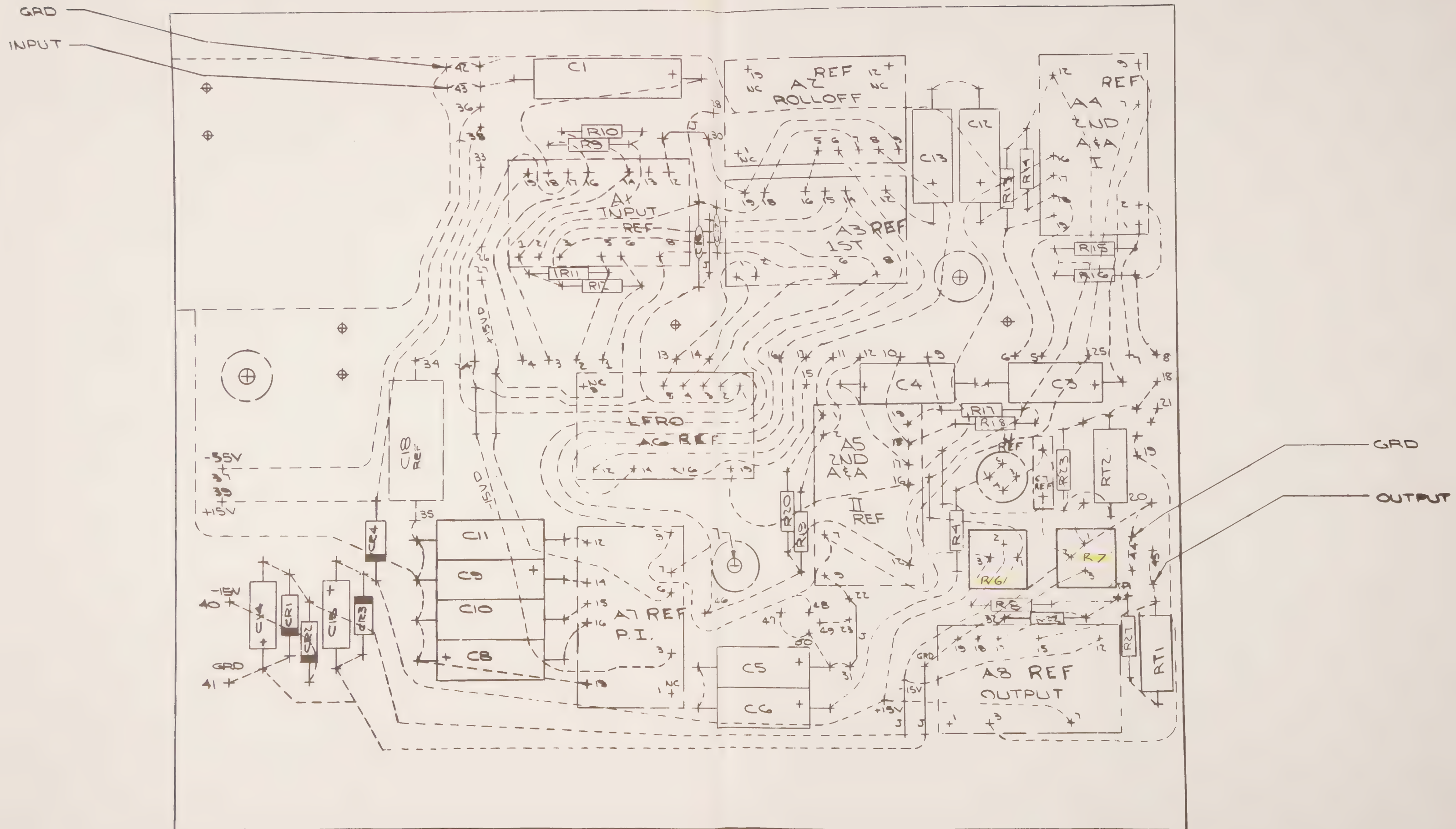




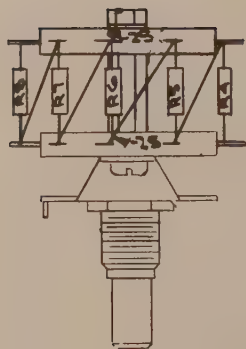
MODEL 454 AMPLIFIER
ASSEMBLY



MODEL 455 AMPLIFIER
ASSEMBLY

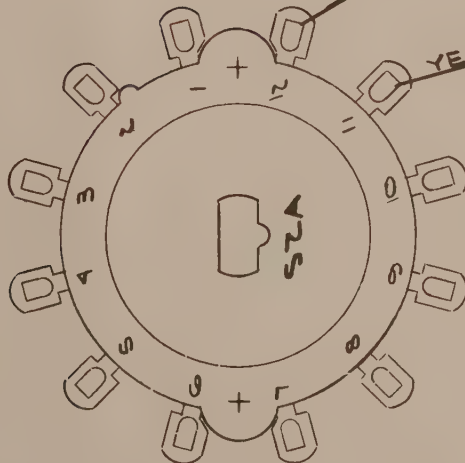
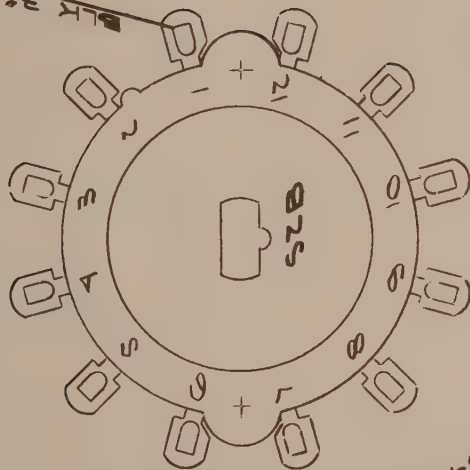


1 dB STEP ATTENUATOR ASSEMBLY



← A

TO A1-20 (GRD)



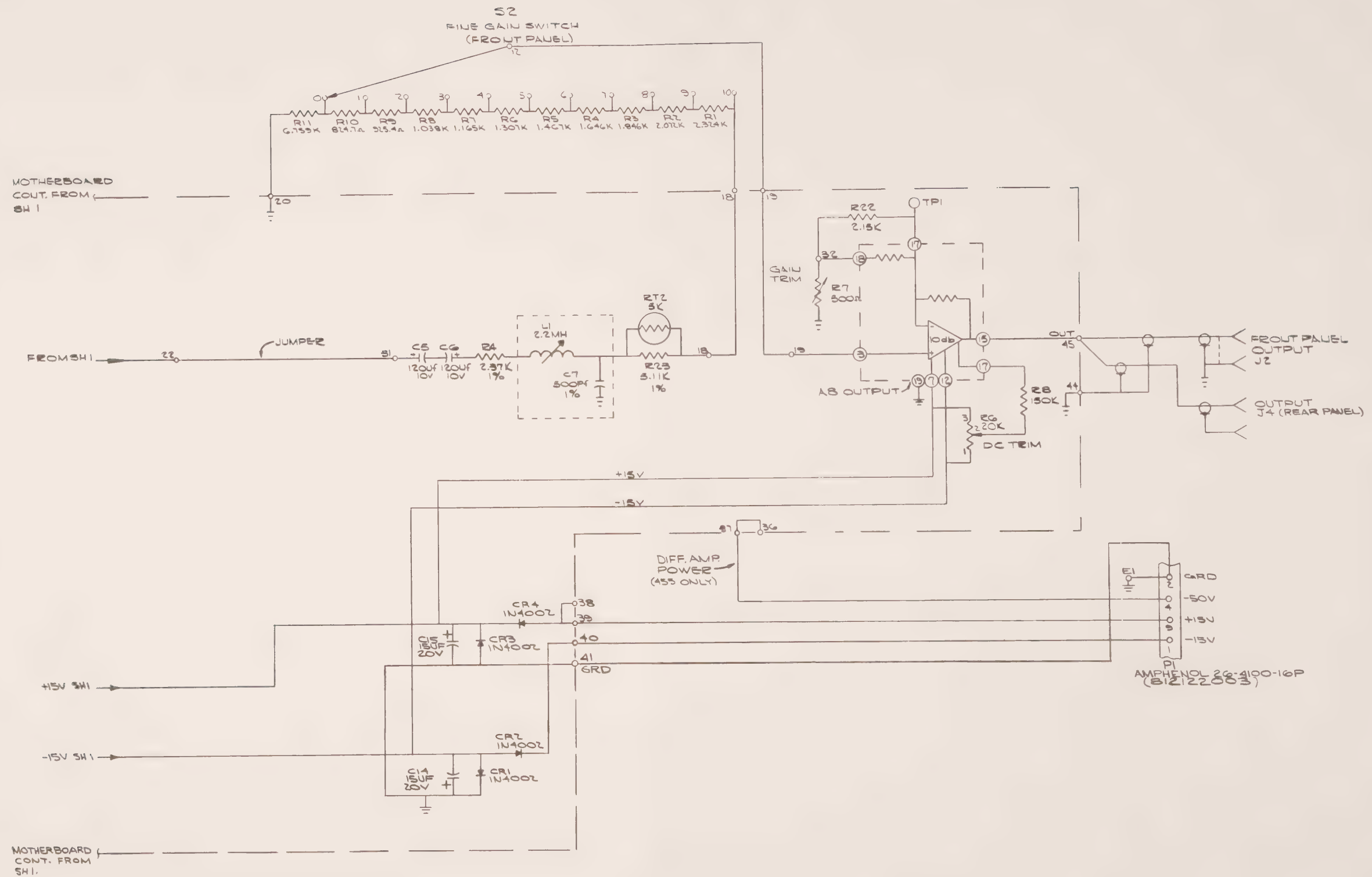
WHT 3-1/2"

YEL 3"

TO A1-18

TO A1-18

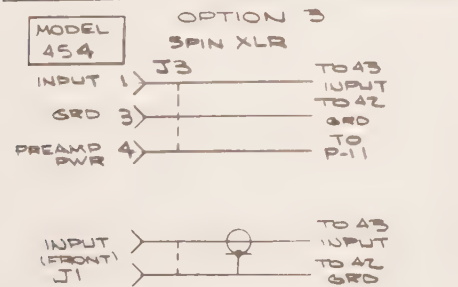
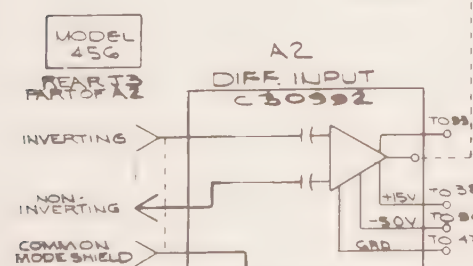
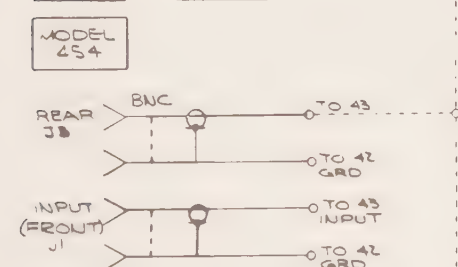
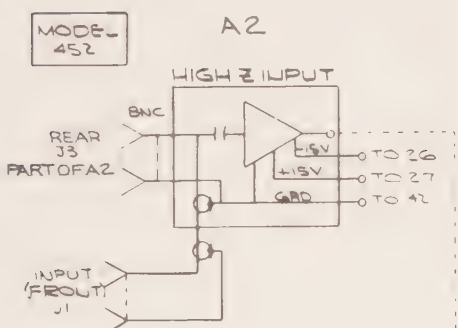
VIEW AT "A" ENLARGED



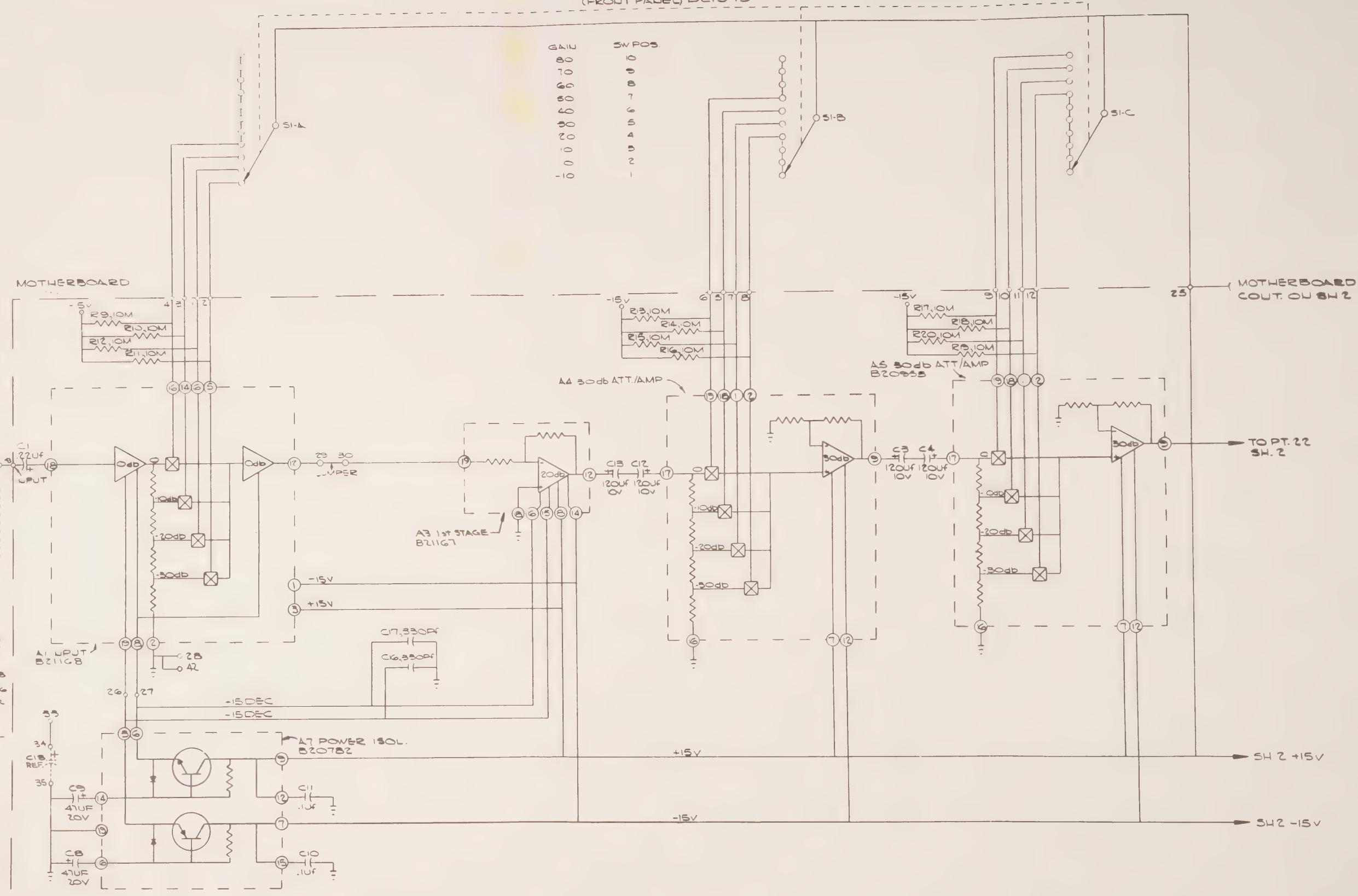
S1
GAINdB
COARSE
(FRONT PANEL) B21373

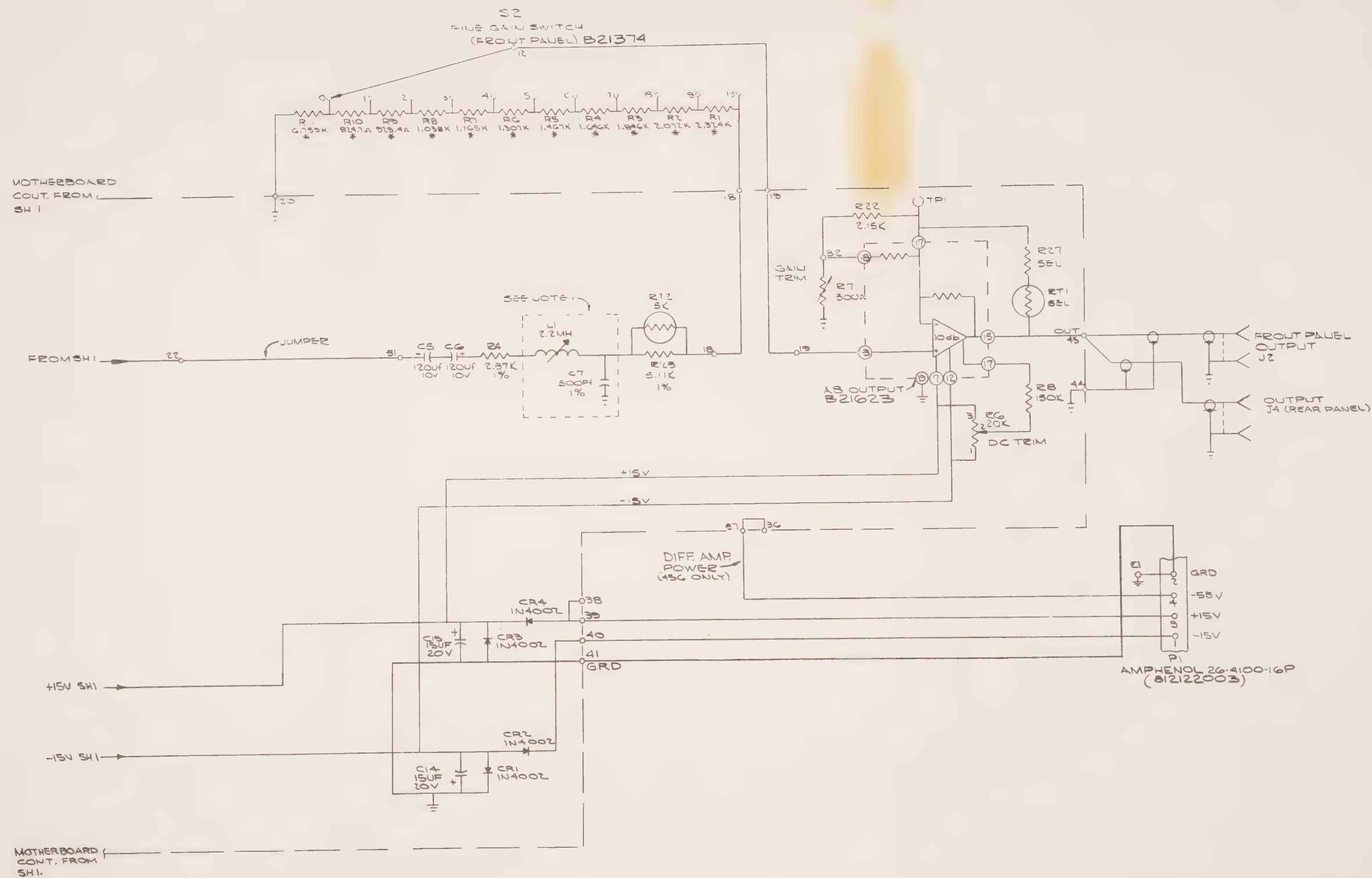
GAIN	SW POS
80	10
70	9
60	8
50	7
40	6
30	5
20	4
10	3
0	2
-10	1

INPUT VARIATIONS



- OPTION 9**
- 5 PIN XLR
- 1 TO A2-43 (INPUT)
 - 2 TO P2-1 (-15V)
 - 3 TO A2-42 (GND)
 - 4 TO A2-9 (+15V)
 - 5 TO A2-42 (GND)





- NOTES:
1. LI & C7 SHOWN FOR STD. 100 K H₂ ROLLOFF
 3. RESISTORS MARKED * ARE 1/8W, 0.1%

SECTION 6

6.0 REPLACEABLE PARTS

6.1 INTRODUCTION

This section contains information for ordering replaceable parts. Tables list parts in alphabetical order of their reference designations and indicates the description and manufacturer's part number. When applicable, a typical manufacturer is indicated.

6.2 REFERENCE DESIGNATIONS AND ABBREVIATIONS

Table 6.1 is a list of reference designations and abbreviations.

6.3 CODE LIST OF MANUFACTURERS

Table 6.3 is a Code List of Manufacturers. The manufacturer's code is given with each part. If a code number is missing, the part is a standard designation and available from many manufacturers.

REFERENCE DESIGNATIONS

A	assembly subassembly, separable or reparable	H	hardware		plug, electrical (connector, movable portion)
AR	amplifier	HR	heater lamp, infrared	PS	power supply
AT	attenuator pad termination	HS	handset	Q	transistor
B	blower motor synchro	HY	network, hybrid circuit	R	potentiometer resistor
BT	battery	J	connector, receptacle, electrical disconnecting device jack receptacle (connector, stationary portion)	RT	lamp, resistance resistor, current regulating resistor, thermal thermistor
C	capacitor	K	relay	RV	resistor, voltage sensitive varistor, symmetrical
CB	circuit breaker	L	coil (all not classified as transformers) inductor	S	switch thermostat
CP	adapter, connector coupling (aperture, loop or probe) junction (coaxial or waveguide)	M	clock counter, electrical meter oscilloscope oscilloscope recorder, elapsed time register, message strain gage thermometer timer, electric	T	transformer
CR	diode rectifier	MK	microphone	TB	strip, terminal terminal board
DS	alarm indicator (excluding meter)	MP	frame gyroscope interlock, mechanical mechanical part mounting (not electrical circuit, not a socket) part, miscellaneous mechanical (bearing, coupling, gear, shaft) part, structural reed, vibration tuning fork	TC	thermocouple
E	antenna arrestor, lightning bimetallic strip cell, aluminum or electrolytic contact core, inductor core, memory core, transformer Hall effect device insulator loop antenna magnet, permanent part, miscellaneous electrical post, binding shield, electrical terminal (individual)	MT	transducer transducer, mode	TP	test point
F	fuse	P	connector, plug, electrical disconnecting device (connector, plug)	U	integrated circuit package
FL	filter			V	cell, light-sensitive, photo- emissive electron tube
G	chopper, electronic generator			W	cable cable assembly (with connectors) wire
				WT	tiepoint, wiring
				X	fuseholder lampholder socket
				Y	crystal unit, piezoelectric

ABBREVIATIONS

A	ampere	GE	germanium	N	nano (10^{-9})	RF	radio frequency
AC	alternating current	GL	glass	N/C	normally closed	RMS	root-means-square
ALUM	aluminum	GND	ground	NE	neon		
AMPL	amplifier			N/O	normally open	S-B	slow-blow
ASSY	assembly	H	henries	NPO	negative positive zero	SCR	screw
		HPF	high-pass filter			SE	selenium
BP	bandpass	HR	hour	NSR	not separately replaceable	SEC	second
		Hz	hertz			SECT	section(s)
CAL	calibration			OSC	oscillator	SEMICON	semiconductor
CAR	carbon	IF	intermediate frequency	OP	operational	SI	silicon
CCW	counterclockwise	INS	insulation(ed)			SIL	silver
CER	ceramic	INT	internal	PC	printed circuit	SL	slide
CKT	circuit			PF	picofarads 10^{-12} farads	SOL	solid
COMP	composition	K	kilo = 1000	PIV	peak inverse volt voltage	SPL	special
CRT	cathode-ray tube	LED	light emitting diode	P/P	part of	TA	tantalum
CW	clockwise	LIN	linear taper	PPM	parts per million	TGL	toggle
dB	decibel	LOG	logarithmic taper	POLY	polystyrene	TOL	tolerance
DC	direct current	LPF	low-pass filter	POLYCARB	poly carbonate	TRIM	trimmer
DET	detector			POS	position(s)		
DVM	digital voltmeter	M	Millo 10^{-3}	POT	potentiometer	μ	micro 10^{-6}
		MEG	meg 10^6	P-P	peak-to-peak	V	volt
ELECT	electrolytic	METFLM	metal film			VAR	variable
ENCAP	encapsulated	MFR	manufacturer	RC	resistor capacitor network	VDCW	dc working volts
EXT	external	MINAT	momentary	RECT	rectifier	VCO	voltage controlled oscillator
F	farads	MOM	momentary	REF	reference	W/	with
FET	field effect transistor	MTG	mounting			WW	watts
FREQ	frequency	MYFLM	"mylar" film			W/O	wirewound without
FXD	fixed						

TABLE 6.1 LIST OF REFERENCE DESIGNATIONS AND ABBREVIATIONS

450 SERIES - D40536G1 MOTHERBOARD

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
CAPACITORS				
C1	.22μF, 200V, 10%, Mylar	811553008	22	W230B1C-224K
C3	120μF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C4	120μF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C5	120μF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C6	120μF, 10V ±10%, Ta	811501075	48	150D127X9010R2
C8	47μF, 20V, ±10%, Ta	811501162	48	150D476X9020R2
C9	47μF, 20V, ±10%, Ta	811501162	48	150D476X9020R2
C10	.1μF, 200V, 10%, Mylar	811553006	22	W230B1C-104K
C11	.1μF, 200V, 10%, Mylar	811553006	22	W230B1C-104K
C12	120μF, 10V, ±10%, Ta	811501075	48	150D127X9010R2
C13	120μF, 10V, ±10%, Ta	811501075	48	150D127X9010R2
C14	15μF, 20V, ±10%, Ta	811501156	48	150D156X9020B2
C15	15μF, 20V, ±10%, Ta	811501156	48	150D156X9020B2
C16	330pF, 1000V, ±10%, Cer	811572014	48	10TS-T33
C17	330pF, 1000V, ±10%, Cer	811572014	48	10TS-T33
DIODES				
CR1	IN4005	818100007		IN4005
CR2	IN4005	818100007		IN4005
CR3	IN4005	818100007		IN4005
CR4	IN4005	818100007		IN4005
RESISTORS				
All resistors not otherwise designated are 1/4W, 5% Comp * 1/8W, 1%, Metflm ** 1/8W, 0.1%, Metflm ***1/10W, 1%, Temp Stable, Metflm				
R4	2.37K*	817211237		RN55D
R6	20K(Pot)	817803203	7	3386P-1-203
R7	500 ohm (Pot)	817803501	7	3386P-1-501
R8	150K	817007154		RC07
R9	10M	817007106		RC07
R10	10M	817007106		RC07

TABLE 6.2 REPLACEABLE PARTS

450 SERIES D 40536G1 MOTHERBOARD (continued)

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
	RESISTORS (continued)			
R11	10M	817007106		RC07
R12	10M	817007106		RC07
R13	10M	817007106		RC07
R14	10M	817007106		RC07
R15	10M	817007106		RC07
R16	10M	817007106		RC07
R17	10M	817007106		RC07
R18	10M	817007106		RC07
R19	10M	817007106		RC07
R20	10M	817007106		RC07
R22	2.15K, *	817211215		RN55D
R23	5.11K, *	817211215		RN55D
R27	Resistor Opt			
RT1	Thermal Opt			
RT2	Thermal 5K	815300003	104	15-5K-54S1

TABLE 6.2 REPLACEABLE PARTS

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B20746G1	31	B20746G1
A1-A2	Asm, Rolloff	B21378G1	31	B21378G1
A1-A3	Asm, 1st Stage	B20745G1	31	B20745G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A6	Asm, LFRO Switch	B20769G1	31	B20769G1
A1-A7	Asm, Pow. Isol.	B20782G1	31	B21782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
A1-C7	Capacitor, 500pF, 500V, 1%, Sil Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J3	Asm, Connector, BNC	A10457G1	31	A10457G1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1
S3	Asm, Switch	B21375G1	31	B21375G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B21168G1	31	B21168G1
A1-A3	Asm, 1st Stage	B21167G1	31	B21167G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A7	Asm, Pwr Isol.	B20782G1	31	B20782G1
A1-A8	Asm, Output Stage	B21623G1	31	B21623G1
A1-C7	Capacitor 500pf, 500V, 1%, Sil Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
A2	Asm, High Z Input Stage	B21231G1	31	B21231G1
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1

TABLE 6.2 REPLACEABLE PARTS

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B20746G1	31	B20746G1
A1-A2	Asm, Rolloff	B21378G1	31	B21378G1
A1-A3	Asm, 1st Stage	B20745G1	31	B20745G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A6	Asm, LFRO Switch	B20769G1	31	B20769G1
A1-A7	Asm, Pwr Isol	B20782G1	31	B20782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
A1-C7	Capacitor, 500pf, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
A2	Asm, High Z Input Stage	B21231G1	31	B21231G1
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1
S3	Asm, Switch	B21375G1	31	B21375G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B21168G1	31	B21168G1
A1-A3	Asm, 1st Stage	B21167G1	31	B21167G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A7	Asm,Pwr Isol	B20782G1	31	B20782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
A1-C7	Capacitor 500pF, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-L1	Choke 2.2mH	811800003	10	3387-27
J1	Connector, BNC	812130110	19	30355-1
J2	Connector, BNC	812130110	19	30355-1
J3	Asm, Connector, BNC	A10457G1	31	A10457G1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	30	B21374G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B20746G1	31	B20746G1
A1-A2	Asm, Rolloff	B21378G1	31	B21378G1
A1-A3	Asm, 1st Stage	B20745G1	31	B20953G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A6	Asm, LFRO Switch	B20769G1	31	B20769G1
A1-A7	Asm, Pwr Isol	B20782G1	31	B20782G1
A1-A8	Asm, Output Stage	B21623G1	31	B21623G1
A1-C7	Capacitor, 500pf, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-C18	Capacitor, 100 μ F, 20V, $\pm$ 10%, Ta	811501166	48	150D107X9020S2
A1-L1	Choke 2.2mH	811800003	10	3387-27
A2	Asm, Diff Input	C30992G2	31	C30992G2
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1
S3	Asm, Switch	B21375G1	31	B21375G1

REFERENCE DESIGNATION	DESCRIPTION	PART NUMBER	MANUFACTURER	
			CODE	PART NUMBER
A1-A1	Asm, Input	B21168G1	31	B21168G1
A1-A3	Asm, 1st Stage	B21167G1	31	B21167G1
A1-A4	Asm, 2nd Stage	B20953G1	31	B20953G1
A1-A5	Asm, 2nd Stage	B20953G1	31	B21953G1
A1-A7	Asm, Pwr Isol	B20782G1	31	B21782G1
A1-A8	Asm, Output	B21623G1	31	B21623G1
CAPACITORS				
A1-C7	500pF, 500V, 1%, Silver Mica	811581015	79	DM-19D501F
A1-C1	100 μ F, 20V, 10%, Ta	811501166	48	150D107X9020S2
A1-L1	Choke, 2.2mH	811800003	10	3387-27
A2	Asm, Diff Input	C30992G2		C30992G2
J2	Connector, BNC	812130110	19	30355-1
J4	Connector, BNC	812130110	19	30355-1
S1	Asm, Switch	B21373G1	31	B21373G1
S2	Asm, Switch	B21374G1	31	B21374G1

CODE LIST OF MANUFACTURERS

1	Aerovox	51	D M Steward Mfg
2	Alco Electronic Prod	52	Switchcraft
3	Allen Bradley		
4	Amphenol Connector	53	Teledyne Semiconductor
5	Analog Devices	54	Teledyne Western Wire and Cable
		55	Texas Instruments
6	Belden	56	Thermalloy
7	Bourns	57	TRW
8	Buckeye Stamping		
9	Bussman Mfg	58	United Transformer
		59	Useco
10	Cambion		
11	Cannon, ITT	60	Vactec
12	Centralab		
13	Cinch Mfg	61	Winchester Electronic
14	C & K Components		
15	Continental-Wirt Elec	62	Vishay
16	Corcom	63	ACI
17	Cornell Dubilier Elec	64	IRC
18	CTS	65	EAL
		66	AMP
19	Dage Electric	67	Clarostat Mfg
20	Delevan Electronics	68	Gould Inc
21	Dresser Systems	69	Littlefuse Inc
22	Electrocube	70	General Illumination
23	Electro Motive Mfg		
24	Electronics Applications	71	Signetrix
25	Erie Technological Products	72	Semiconductor Cir
		73	Statek
26	Fairchild Semiconductor	74	Bendix
27	Federal Screw Prod	75	Burndy
		76	American Handle Sales
28	General Electric	77	Varo Semiconductor
		78	Dialco
29	Helipot	79	Elmenco
30	Heyman Mfg	80	Amp Incorporated
31	ITHACO	81	Berg
		82	Comp Corp
32	E F Johnson	83	Hewlett-Packard
		84	Beckman Helipot
33	Litronix	85	Raytheon
		86	Intersil
34	Marco-Oak Industries	87	A H & H
35	Motorola Semiconductor Prod	88	ADC Products
		89	Scanbe
36	National Semiconductor	90	Drake
		91	Victoreen
37	Ohmite Mfg	92	Frost
		93	Sigma
38	Paktron	94	Becon
39	Panduit	95	Microswitch
40	Pomona Electronics	96	Wavetek
41	Product Components	97	Electronic Concepts
42	Pyrofilm	98	Amelco
		99	Mepco
43	RCL Electronics	100	RCA
44	Rembrandt	101	Circuit Asm Corp
45	Rogan	102	Monsanto
		103	Ainsley
46	Schauer Mfg	104	Keystone Carbon
47	H H Smith		
48	Sprague Electric		
49	Spectrol Electronics		
50	Stancor		

TABLE 6.3 CODE LIST OF MANUFACTURERS

WARRANTY

ITHACO Inc. warrants each instrument to be free of defects in material and workmanship for a period of one year after shipment to the original purchaser; batteries are specifically excluded. Liability under this warranty is limited to repairing or adjusting any instrument returned to the factory for that purpose. The warranty of this instrument is void if the instrument has been modified other than in accordance with written instructions from ITHACO, or if defect or failure is judged by ITHACO to be caused by abnormal conditions of operation, storage or transportation.

This warranty is subject to verification by ITHACO, that a defect or failure exists, and to compliance by the original purchaser with the following instructions:

1. Before returning the instrument, notify ITHACO with full details of the problem; include model number and serial number of the instrument involved.
2. After receiving the above information, ITHACO will give you shipping instructions or service instructions. After receipt of shipping instructions, ship the instrument to ITHACO. Full liability for damage during shipment is borne by the purchaser. It is recommended that instruments shipped to us be fully insured and packed surrounded by at least 2 inches of shock-absorbing material.

ITHACO reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of ITHACO, and ITHACO neither assumes, nor authorizes any other person to assume for it, any liability in connection with the sales of ITHACO instruments.

ITHACO INC.
735 W. Clinton Street
Ithaca, New York 14850
Telephone: 607-272-7640



WARRANTY

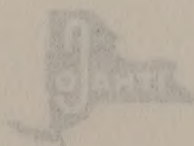
THACO Inc. warrants each instrument to be free of defects in material and workmanship for a period of one year after shipment to the original purchaser. This warranty is specifically extended to the purchaser only and is limited to replacement or a refund of the purchase price. The warranty of this instrument is void if the instrument has been modified, altered, or repaired by THACO or its agents, or if it is damaged or lost. This warranty is limited to the original purchaser and is not transferable.

This warranty is subject to verification by THACO that a defect in fact exists, and is supplemented by the original purchaser with the following restrictions:

1. Before returning the instrument, notify THACO with full details of the instrument, make, model, number and serial number of the instrument involved.
2. After receiving the above information, THACO will give you shipping instructions or return instructions. First class airmail return shipping charges will be paid by THACO. It is recommended that instruments be shipped in the original box and packed surrounded by at least 2 inches of absorbent material.

THACO reserves the right to make changes in design at any time without incurring any obligation to notify same to units previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of THACO and THACO neither assumes, nor authorizes any representative to assume for it, any liability in connection with the sale of THACO instruments.



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